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DIODE

STEP STRESS TESTING PROGRAM

MSFC/NASA CONTRACT NUMBER
NAS8-31944

FINAL REPORT
FOR

JANTX 1N937B

FEBRUARY 1979

Prepared
For

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NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
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FOREWORD

This is a summary of the work performed on NASA Contract NAS8-31944. The investigation was conducted for the National Aeronautics and Space Administration, George C. Marshall Space Flight Center, Huntsville, Alabama. The Contracting Officer's Technical Representative was Mr. F. Villella.

The short-term objective of this preliminary study of transistors, diodes, and FETS is to evaluate the reliability of these discrete devices, from different manufacturers, when subjected to power and temperature step stress tests.

The long-term objective is to gain more knowledge of accelerated stress testing for use in future testing of varieties of discrete devices, as well as to determine which type of stress should be applied to a particular type of device or design.

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1.0 INTRODUCTION

DCA Reliability Laboratory, under Contract NAS8-31944 for NASA/Marshall Space Flight Center, has compiled data for the purpose of evaluating the effect of power/temperature step stress when applied to a variety of semiconductor devices. This report covers the zener diode JANTX1N937B manufactured by Motorola and Siemens.

A total of 48 samples from each manufacturer were submitted to the process outlined in Table 1. In addition, two control sample units were maintained for verification of the electrical parametric testing.

2.0 TEST REQUIREMENTS

2.1 Electrical

All test samples were subjected to the electrical tests outlined in Table 2 after completing the prior power/temperature step stress point. These tests were performed using the Fairchild Model 600 high-speed computer-controlled tester. Additional bench testing was also required on the devices.

2.2 Stress Circuit

The test circuit shown in Figure 1 was used to power all of the test devices during the power/temperature stress conditions. The voltage was set by V_Z and the current was varied in order to comply with the specified power rating for this device. At least one of the devices was subjected to maximum rated power (MRP). All remaining devices were subjected to no less than 90% of MRP. See Figure 1 for load resistance values and voltages.

2.3 Group I - Power Stress

Thirty-two units, 16 from each manufacturer, were submitted to the power stress process. The diodes were stressed in 500-hour steps at 50, 100, 125, 150, and 175 percent of maximum rated power for 2500 hours or until 50% or more of the devices in a sample lot failed.* Electrical measurements were performed on all specified electrical parameters after each power step. See Table 1.

2.4 Group II - Temperature Stress I

Thirty-two units, 16 from each manufacturer, were submitted to the Temperature Stress I Process. Group II was subjected to 1600 hours of stress at maximum rated power in increments of 160 hours. The temperature was increased in steps of 25°C, commencing at 75°C and terminating at 300°C or until 50% or more of the devices failed.* Electrical measurements were performed on all specified electrical parameters after each temperature step. See Table 1.

2.5 Group III - Temperature Stress II

Thirty-two units, 16 from each manufacturer, were submitted to the Temperature Stress II process. Group III was subjected to 112 hours of stress at maximum rated power in increments of 16 hours. The temperature was increased in steps of 25°C, commencing at 150°C and terminating at 300°C or until 50% or more of the devices in the sample lot failed.* Electrical measurements were performed on all specified electrical parameters after each temperature step. See Table 1.

* Conditions for failure:
A) Open or short
B) Leakage exceeds the maximum limit by 100 times
C) Other parameters exceed MIL limits by 50% or more.

3.0 DISCUSSION OF TEST RESULTS

3.1 Group I - Power Stress

3.1.1 Motorola. The Motorola sample lot completed 2150 hours of Group I Testing before the lot was stopped because 50% of the devices failed. The first two failures occurred 150 hours into the 150% MRP step. Serial numbers 5236 and 5242 failed the minimum B_V limit. The next failure occurred 10 hours into the 175% MRP step. Serial number 5229 failed the minimum B_V limit. The next failure occurred 50 hours into the 175% MRP step. Serial number 5227 failed the minimum B_V limit. The last four failures occurred 150 hours into the 175% MRP step. Serial numbers 5230, 5235, 5237, and 5239 failed the minimum B_V limit. Typical characteristics of this sample lot's performance were:

1) The mean value for B_V changed 4.326V from an initial mean of 8.958V to a final mean of 4.632V.

The control units for this sample lot remained constant throughout the entire Group I Testing.

3.1.2 Siemens. The Siemens sample lot completed 2010 hours of Group I Testing before the lot was stopped because more than 50% of the devices failed. The first failure occurred 250 hours into the 100% MRP step. Serial number 5180 failed the minimum B_V limit. Serial number 5173 was recorded as a missing part 500 hours into the 100% MRP step. The next failure occurred 50 hours into the 125% MRP step. Serial number 5185 failed the minimum B_V limit. The next failure occurred 10 hours into the 150% MRP step. Serial number 5183 failed the

minimum B_V limit. The next failure occurred 25 hours into the 150% MRP step. Serial number 5188 failed the minimum B_V limit. The next failure occurred 150 hours into the 150% MRP step. Serial number 5176 failed the minimum B_V limit. The last four failures occurred 10 hours into the 175% MRP step. Serial numbers 5174, 5177, and 5181 failed the minimum B_V limit. Serial number 5182 failed the maximum B_V limit. Typical characteristics of this sample lot's performance were:

1) The mean value for B_V changed 4.609V from an initial mean of 9.159V to a final mean of 4.550V.

The control units for this sample lot remained constant throughout the entire Group I Testing.

3.1.3 Statistical Summary - Group I

Table 4 outlines the results of Group I - Power Stress Testing for the electrical parameter and all of the measurement points for both Motorola and Siemens.

3.2 Group II - Temperature Stress I

3.2.1 Motorola. The Motorola sample lot completed the entire 1600-hour Group II Testing with six catastrophic failures. The first failure occurred 160 hours into the 200°C-temperature step. Serial number 5255 failed the minimum B_V limit. The next three failures occurred 160 hours into the 275°C-temperature step. Serial numbers 5249, 5253, and 5258 failed the minimum B_V limit. The last two failures occurred 160 hours into the 300°C-temperature step. Serial numbers 5247 and 5259 failed the minimum B_V limit. Typical characteristics of this sample lot's performance were:

1) The mean value for B_V changed 3.198V from an initial mean of 8.933V to a final mean of 5.735V.

The control units for this sample lot remained constant throughout the entire Group II Testing.

3.2.2 Siemens. The Siemens sample lot completed the entire 1600-hour Group II Testing with nine catastrophic failures. The first failure occurred 160 hours into the 175°C-temperature step. Serial number 5190 failed the minimum B_V limit. The next two failures occurred 160 hours into the 250°C-temperature step. Serial numbers 5203 and 5204 failed the minimum B_V limit. The next three failures occurred 160 hours into the 275°C-temperature step. Serial numbers 5195, 5197, and 5202 failed the minimum B_V limit. The last three failures occurred 160 hours into the 300°C-temperature step. Serial numbers 5189, 5193, and 5199 failed the minimum B_V limit. Typical characteristics of this sample lot's performance were:

1) The mean value for B_V changed 4.225V from an initial mean of 9.121V to a final mean of 4.896V.

The control units for this sample lot remained constant throughout the entire Group II Testing.

3.2.3 Statistical Summary - Group II. Table 5 outlines the results of Group II - Temperature Stress I Testing for the electrical parameter and all of the measurement points for both Motorola and Siemens.

3.3 Group III - Temperature Stress II

3.3.1 Motorola. The Motorola sample lot completed the entire 112-hour Group III testing with one catastrophic failure. Serial numbers 5271 and 5269 were removed

from the Group III Testing as MIL-STD-19500 limit failures 16 hours into the 200°C- and 225°C-temperature steps, respectively. The catastrophic failure occurred 16 hours into the 250°C-temperature step. Serial number 5261 failed the minimum B_V limit. Typical characteristics of this sample lot's performance were:

1) The mean value for B_V changed .552V from an initial mean of 8.925V to a final mean of 8.373V.

The control units for this sample lot remained constant throughout the entire Group III Testing.

3.3.2 Siemens. The Siemens sample lot completed the entire 112-hour Group III Testing with six catastrophic failures. The first four failures occurred 16 hours into the 200°C-temperature step. Serial numbers 5206, 5214, 5218, and 5219 failed the minimum B_V limit. The last two failures occurred 16 hours into the 300°C-temperature step. Serial numbers 5210 and 5212 failed the minimum B_V limit. Typical characteristics of this sample lot's performance were:

1) The mean value for B_V changed 1.443V from an initial mean of 9.107V to a final mean of 7.664V.

The control units for this sample lot remained constant throughout the entire Group III Testing.

3.3.3 Statistical Summary - Group III. Table 6 outlines the results of Group III - Temperature Stress II Testing for the electrical parameter and all of the measurement points for both Motorola and Siemens.

4.0 FINAL DATA SUMMARY

Table 7 statistically summarizes the change in the mean value from the zero-hour data to the final data. The graphs of Figures 2 and 4 plot the cumulative percent failures versus the temperature stress level for Group II - Temperature Stress I, and Group III - Temperature Stress II. The graphs of Figures 3 and 5 plot the time step for Group II (160 hours) and Group III (16 hours) versus the temperatures T_1 and T_2 calculated from Figures 2 and 4. Tables 8 and 9 summarize the failures encountered for all three stress groups. The failures are separated into two categories: catastrophic failures in Table 8 and parametric failures in Table 9. The data from Table 8 was used as a source for the graphs in Figures 2 and 4. Figures 2 and 4 were used as a source for the graphs in Figures 3 and 5 respectively. Junction temperature is plotted on an inverse hyperbolic scale.

5.0 CONCLUSIONS

The apparent failure mode in all three stress groups was the B_V minimum failure. Although both manufacturers had approximately the same amount of failures in each testing, the Motorola failures came later in the testings than those in the Siemens sample lots.

The Siemens and Motorola diodes are constructed with two anode dice forward biased and one cathode die reverse biased. When failure analysis was performed one anode die was operational, and the reverse biased dice on many of the failures exhibited soft resistive

curves. This indicates damage to the junctions due to micro-plasmas induced by the thermal and electrical stress of the burn-in.

A plot showing cumulative failure distribution for Groups II and III was drawn for the Motorola sample lot (Figures 2 and 3), but a complete plot for the Siemens sample lot could not be drawn due to an absence of main failure points in the Group III Testing (Figures 4 and 5). Figures 2 and 3 display the data for the Motorola sample lot used to calculate an activation energy of 1.95eV.

A broken circle around a marked point on the graph indicates a freak failure not calculated as part of the regression line. A solid circle around a marked point indicates an isolated failure point. The regression line was calculated using the least squares method.

The activation energy was calculated from the formula:

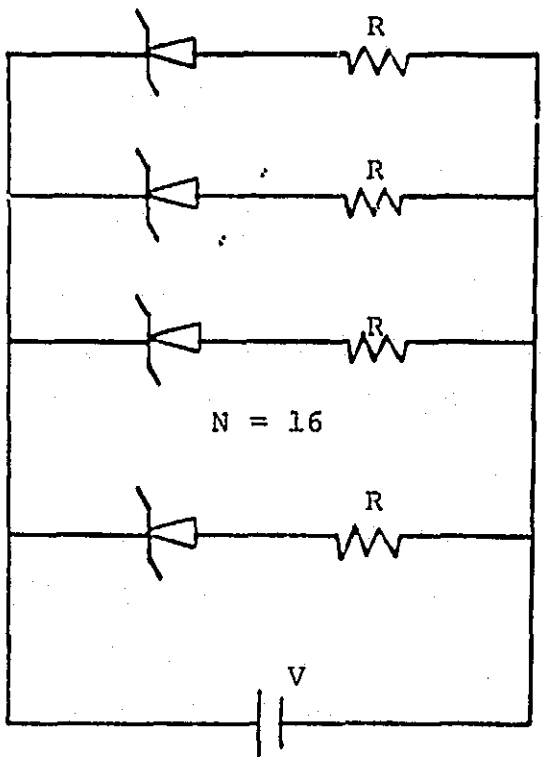
$$E = \left[\ln \left(\frac{t_1}{t_2} \right) \right] \left[\frac{8.63 \times 10^{-5} \text{ eV/}^{\circ}\text{K}}{\left(\frac{1}{T_1+273} \right) - \left(\frac{1}{T_2+273} \right)} \right] \text{ eV}$$

Where:
- t_1 = step of Group II - Temp Stress I = 160 hrs.
- t_2 = step of Group III - Temp Stress II = 16 hrs.
- T_1 = temperature in $^{\circ}$C of 16% failure for Group II.
- T_2 = temperature in $^{\circ}$C of 16% failure for Group III.

FIGURE 1

JANTX1N937B

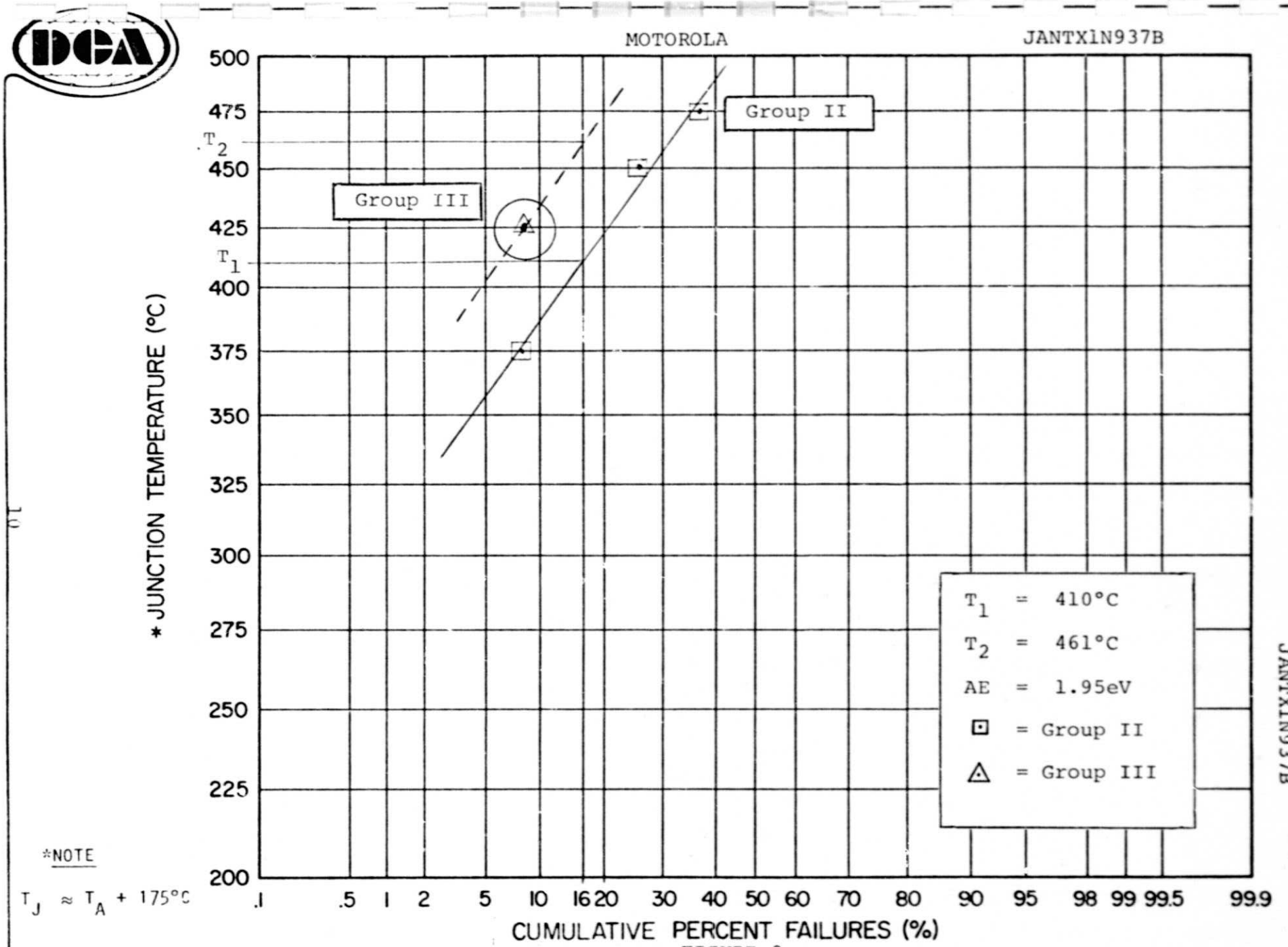
ZENER DIODES



$R = VZ \div 1.75\ IZ_{MAX} \pm 50\%$

$P_d = VZ^2 \div R$

Power/Temperature Stress Circuit
for JANTX1N937B



*NOTE

$T_J \approx T_A + 175°C$

FIGURE 2

Cumulative Percent Failures Versus Junction Temperature, Motorola

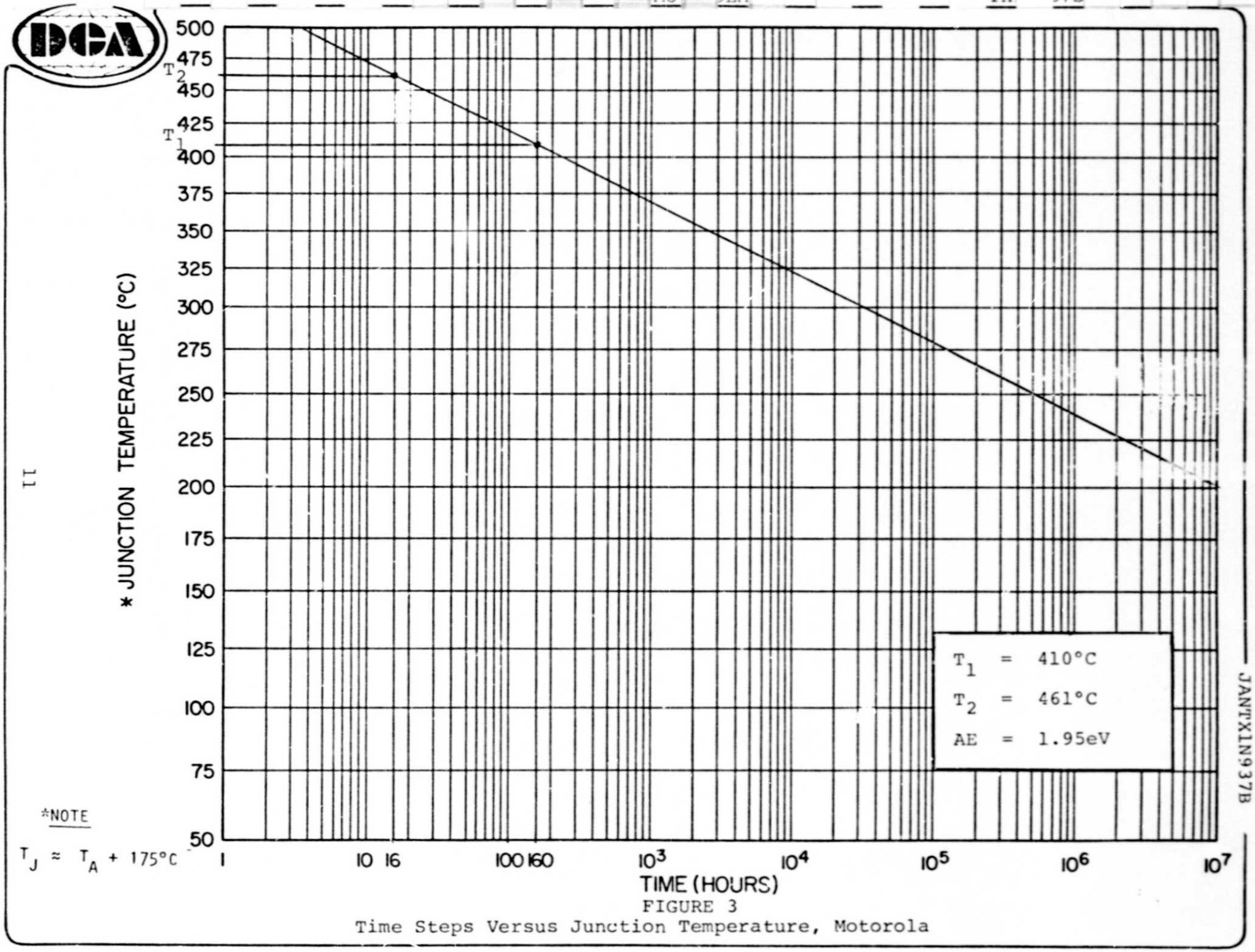
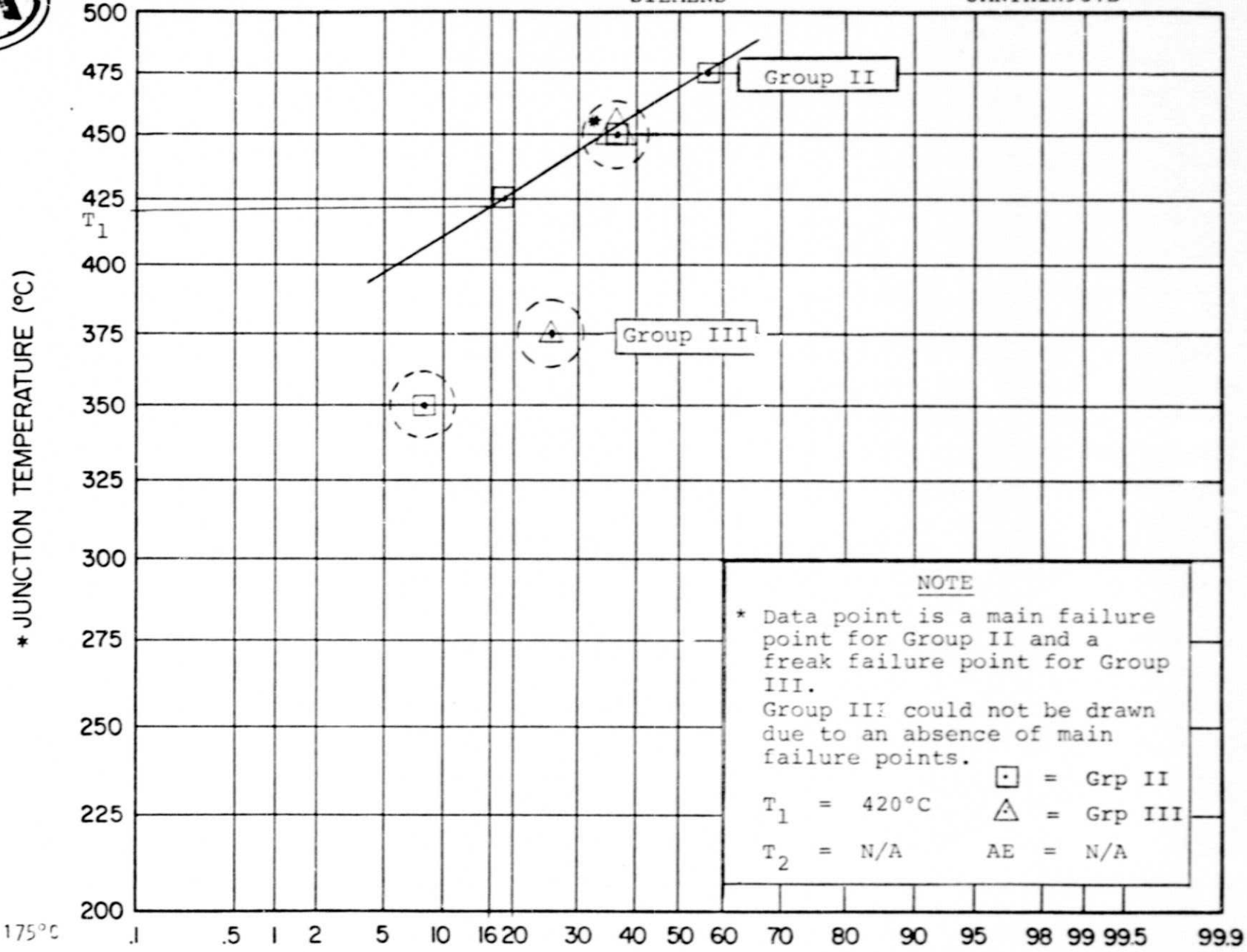


FIGURE 3
Time Steps Versus Junction Temperature, Motorola



*NOTE

$T_J \approx T_A + 175°C$

FIGURE 4
Cumulative Percent Failures Versus Junction Temperature, Siemens

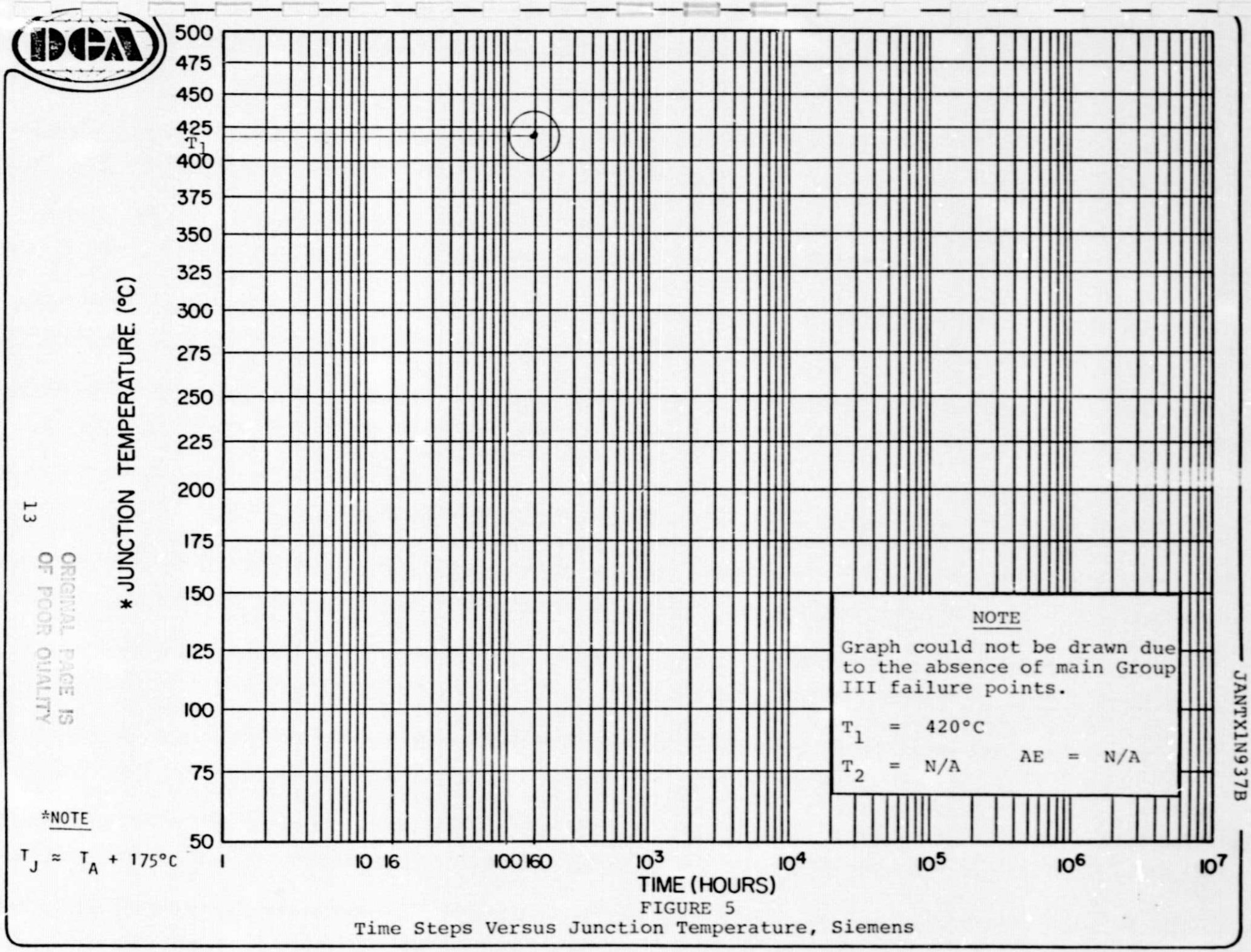
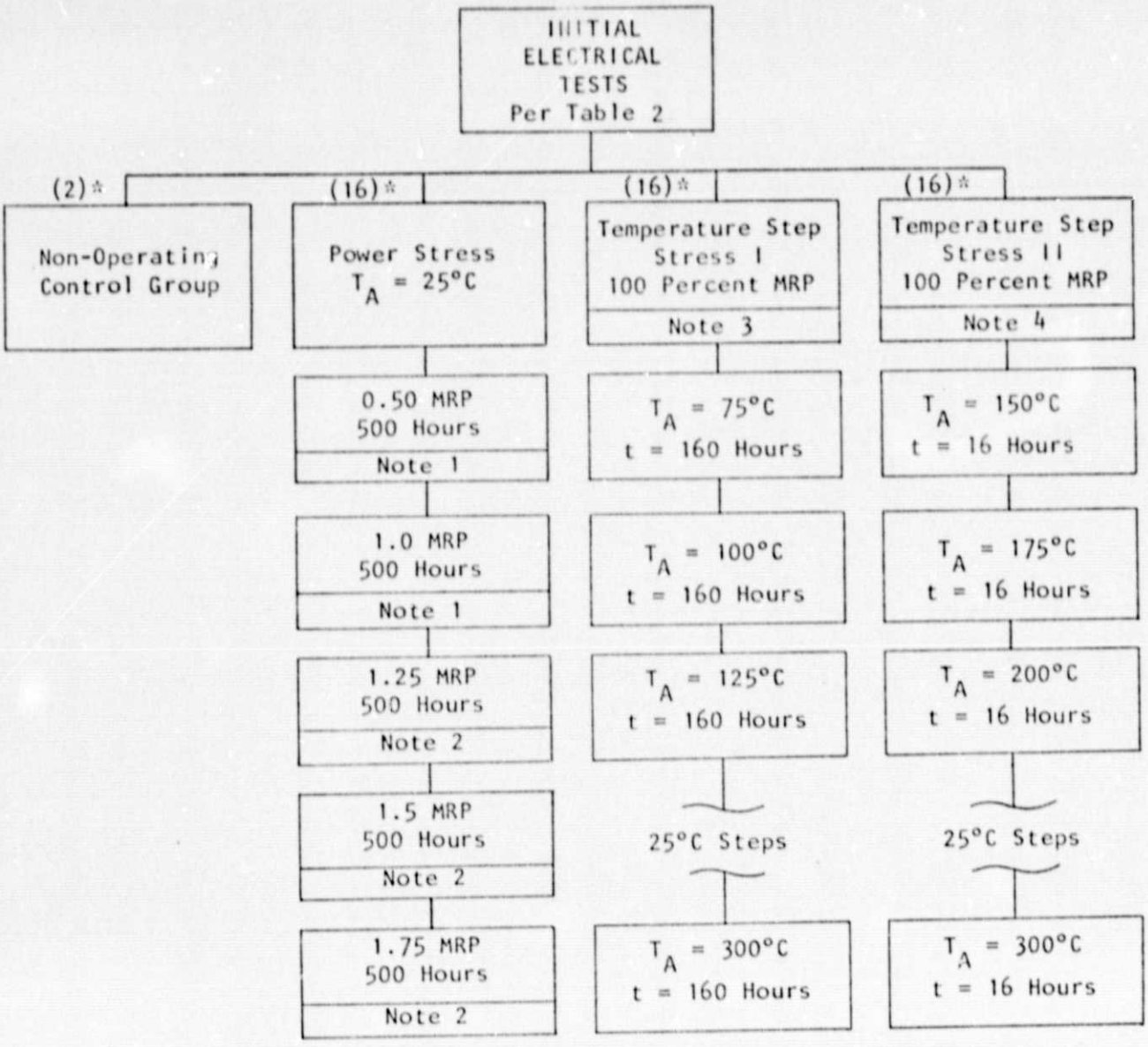


FIGURE 5
Time Steps Versus Junction Temperature, Siemens

TABLE 1
TEST FLOW DIAGRAM



*Quantity per manufacturer (Motorola and Siemens)

NOTES:

1) Electrical measurements per Table 2 were made at 50, 150, 250 and 500 hours.
2) Electrical measurements per Table 2 were made at 10, 25, 50, 150, 250 and 500 hours.
3) Electrical measurements per Table 2 were made at the end of each 160 hours.
4) Electrical measurements per Table 2 were made at the end of each 16 hours.

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TABLE 2

PARAMETERS AND TEST CONDITIONS

		SPEC LIMITS		CAT. LIMITS *		
PARAMETER	CONDITIONS	MIN	MAX	MIN	MAX	UNITS
B_V	@ $I_Z = 7.5 \pm .01$mA	8.55	9.45	4.275	14.175	V

NOTES: * In addition, any open or short shall be considered catastrophic.

TABLE 3

POWER STRESS BURN-IN CONDITIONS

$V_Z = 9.0V$	
$I_Z =$	% P_D
27.5mA	50
55.0mA	100
68.75mA	125
82.5mA	150
96.25mA	175

NOTE
FOR TABLES
4 THROUGH 7

The minimum/maximum initial and final data generally have an absolute accuracy of ± 1% of the reading and ± one digit except for readings greater the 9.99mA which have an absolute accuracy of ± 2% of the reading and ± one digit. The data also has a resolution for four digits. The standard diviations, means, delta means, and average means are, therefore, valid indicators of trends over time and temperature, excepting the minor statistical computer error of supplying a constant number of significant digits.

NOTE
FOR TABLES
4 THROUGH 7

The minimum/maximum initial and final data generally have an absolute accuracy of ± 1% of the reading and ± one digit except for readings greater the 9.99mA which have an absolute accuracy of ± 2% of the reading and ± one digit. The data also has a resolution for four digits. The standard diviations, means, delta means, and average means are, therefore, valid indicators of trends over time and temperature, excepting the minor statistical computer error of supplying a constant number of significant digits.

TABLE 4
GROUP I – POWER STRESS DATA SUMMARY

PARAMETER	B_V=8.55V(MIN) 9.45V(MAX)							
CONDITIONS AND LIMIT	@ I_Z=7.5±.01mA							
IDENTIFICATION	MOTOROLA	SIEMENS						
INITIAL DATA								
MIN VALUE	8.640V	8.953V						
MAX VALUE	9.084V	9.366V						
MEAN	8.958V	9.159V						
STD DEV	.1404V	.08528V						
INTERIM DATA								
POWER 50 TO 125% Δ MEAN VALUE								
50% POWER								
50 Hours	-.001V	-.001V						
150 Hours	-.000V	-.000V						
250 Hours	-.001V	-.001V						
500 Hours	-.001V	-.001V						
100% POWER								
550 Hours	+.007V	-.004V						
650 Hours	+.013V	*-.276V						
750 Hours	+.017V	-.010V						
1000 Hours	+.016V	-.009V						
125% POWER								
1010 Hours	+.018V	-.010V						
1025 Hours	+.191V	-.010V						
1050 Hours	+.018V	-.013V						
1150 Hours	+.019V	-.008V						
1250 Hours	+.018V	+.004V						
1500 Hours	+.018V	-.002V						

(continued on second sheet)

TABLE 4 (Cont'd)
GROUP I — POWER STRESS DATA SUMMARY

(continued from first sheet)

PARAMETER	B_V=8.55V(MIN) 9.45V(MAX)							
CONDITIONS AND LIMITS	@ I_Z=7.5±.01mA							
IDENTIFICATION	MOTOROLA	SIEMENS						
INITIAL DATA								
MIN VALUE	8.640V	8.953V						
MAX VALUE	9.084V	9.366V						
MEAN	8.958V	9.159V						
STD DEV	.1404V	.08528V						
INTERIM DATA								
POWER 150 TO 175% Δ MEAN VALUE								
150% POWER								
1510 Hours	+.014V	*-.694V						
1525 Hours	+.016V	*-1.416V						
1550 Hours	-.020V	-.614V						
1650 Hours	*-.471V	*-1.075V						
1750 Hours	-.501V	-2.201V						
2000 Hours	-1.552V	-2.405V						
175% POWER								
2010 Hours	*-1.909V	*-4.609V						
---	---	---						
2025 Hours	-2.022V	Job Stopped						
2050 Hours	*-2.215V							
2150 Hours	*-4.326V							
---	---							
2250 Hours	Job Stopped							
2500 Hours								
FINAL DATA								
MIN VALUE	.967V	1.388V						
MAX VALUE	8.681V	6.055V						
MEAN	4.632V	4.550V						
STD DEV	2.644V	1.393V						

NOTE: Catastrophic Rejects removed from data.

TABLE 5

JANTX1N937B

GROUP II TEMP STRESS I DATA SUMMARY

PARAMETERS	B_V=8.55V(MIN) 9.45V(MAX)							
CONDITIONS AND LIMITS	@ I_Z=7.5±.01mA							
IDENTIFICATION	MOTOROLA	SIEMENS						
INITIAL DATA								
MIN VALUE	8.664V	8.926V						
MAX VALUE	9.065V	9.221V						
MEAN	8.933V	9.121V						
STD DEV	.1466V	.07639V						
INTERIM DATA (INITIAL TO FINAL)								
Δ MEAN VALUE								
Total Hours / Temp(T_A)								
160 / 75°C	+.003V	-.005V						
320 / 100°C	+.016V	-.007V						
480 / 125°C	+.019V	-.025V						
640 / 150°C	-.116V	-.025V						
800 / 175°C	-.245V	*-.433V						
960 / 200°C	*-.444V	-.632V						
1120 / 225°C	-1.684V	-1.872V						
1280 / 250°C	-2.525V	*-2.713V						
1440 / 275°C	*-3.297V	*-4.104V						
1600 / 300°C	*-3.198V	*-4.225V						
FINAL DATA								
FINAL TEMP	300°C	300°C						
MIN VALUE	1.365V	1.554V						
MAX VALUE	7.065V	7.719V						
MEAN	5.735V	4.896V						
STD DEV	1.488V	1.439V						

NOTE: CATASTROPHIC REJECTS REMOVED FROM DATA

DCA Form 1800-1

TABLE 6 JANTX1N937B

GROUP III TEMP STRESS II DATA SUMMARY (16 Hours)

PARAMETERS	B_V=8.55V(MIN) 9.45V(MAX)							
CONDITIONS AND LIMITS	@ I_Z=7.5±.01mA							
IDENTIFICATION	MOTOROLA	SIEMENS						
INITIAL DATA								
MIN VALUE	8.654V	8.730V						
MAX VALUE	9.109V	9.268V						
MEAN	8.925V	9.107V						
STD DEV	.1765V	.1310V						
INTERIM DATA (INITIAL TO FINAL)								
Δ MEAN VALUE								
Total Hours / Temp(T_A)								
16 / 150°C	+.010V	-.008V						
32 / 175°C	+.013V	-.005V						
48 / 200°C	+.017V	*-1.427V						
64 / 225°C	+.004V	-.100V						
80 / 250°C	*-.450V	-.721V						
96 / 275°C	-.486V	*-.969V						
112 / 300°C	-.552V	-1.443V						
FINAL DATA								
FINAL TEMP	300°C	300°C						
MIN VALUE	4.455V	4.289V						
MAX VALUE	9.122V	9.127V						
MEAN	8.373V	7.664V						
STD DEV	1.199V	1.619V						

NOTE: CATASTROPHIC REJECTS REMOVED FROM DATA

DCA Form 1800-1

TABLE 7
FINAL DATA SUMMARY

PARAMETER	SPECIFICATIONS LIMIT		UNITS	MEAN INT. DATA	AVERAGE Δ IN MEAN VALUE					
					POWER STRESS		TEMPERATURE STRESS I		TEMPERATURE STRESS II	
	MIN	MAX								
B_V	8.55	9.45	V		* -.52725	* -.63595	* -1.1471	* -1.4041	* -.20629	* -.66757

* NOTE: Catastrophic reject(s) removed from data.

TABLE 8 STEP STRESS CATASTROPHIC FAILURE SUMMARY JAN TX1N937B

GROUP I POWER STRESS

TEST STEP	MFR A		MFR B	
	QTY.	NOTE	QTY.	NOTE
50% 50 hr.	0	-	0	-
100 hr.	0	-	0	-
100 hr.	0	-	0	-
250 hr.	0	-	0	-
100% 50 hr.	0	-	0	-
100 hr.	0	-	0	-
100 hr.	0	-	1	A
250 hr.	0	-	0	-
125% 10 hr.	0	-	0	-
15 hr.	0	-	0	-
25 hr.	0	-	1	A
100 hr.	0	-	0	-
100 hr.	0	-	0	-
250 hr.	0	-	0	-
150% 10 hr.	0	-	1	A
15 hr.	0	-	1	A
25 hr.	0	-	0	-
100 hr.	2	A	1	A
100 hr.	0	-	0	-
250 hr.	0	-	0	-
175% 10 hr.	1	A	3 / 1	A / B
15 hr.	0	-	Job Stopped	
25 hr.	1	A		
100 hr.	4	A		
100 hr.	Job Stopped			
250 hr.	↓	↓	↓	↓

GROUP II 160 HR. TEMP. STEPS

TEST STEP TA	MFR A		MFR B	
	QTY.	NOTE	QTY.	NOTE
75° C	0	-	0	-
100° C	0	-	0	-
125°C	0	-	0	-
150°C	0	-	0	-
175°C	0	-	1	A
200°C	1	A	0	-
225°C	0	-	0	-
250°C	0	-	2	A
275°C	3	A	3	A
300°C	2	A	3	A

GROUP III 16 HR. TEMP. STEPS

TEST STEP TA	MFR A		MFR B	
	QTY.	NOTE	QTY.	NOTE
150°C	0	-	0	-
175°C	0	-	0	-
200°C	0	-	4	A
225°C	0	-	0	-
250°C	1	A	0	-
275°C	0	-	2	A
300°C	0	-	0	-

MFR "A" = Motorola

MFR "B" = Siemens

NOTES:

(A) $B_V < 4.275V$

(B) $B_V > 14.175V$

TABLE 9 STEP STRESS PARAMETRIC FAILURE SUMMARY JAN TX1N937B

GROUP I POWER STRESS

TEST STEP	MFR A		MFR B	
	QTY.	NOTE	QTY.	NOTE
50% 50 hr.	0	-	0	-
100 hr.	0	-	0	-
100 hr.	0	-	0	-
250 hr.	0	-	0	-
100% 50 hr.	0	-	0	-
100 hr.	0	-	1	A
100 hr.	0	-	0	-
250 hr.	0	-	1	C
125% 10 hr.	0	-	0	-
15 hr.	0	-	0	-
25 hr.	0	-	0	-
100 hr.	0	-	0	-
100 hr.	0	-	0	-
250 hr.	0	-	0	-
150% 10 hr.	0	-	4	A
15 hr.	0	-	1	A
25 hr.	1 / 1	A / B	0	-
100 hr.	1	A	3	A
100 hr.	5	A	2	A
250 hr.	5	A	1 / 1	A / B
175% 10 hr.	0	-	0	-
15 hr.	0	-	Job Stopped	
25 hr.	0	-		
100 hr.	0	-		
100 hr.	Job Stopped			
250 hr.				

GROUP II 160 HR. TEMP. STEPS

TEST STEP T_A	MFR A		MFR B	
	QTY.	NOTE	QTY.	NOTE
75° C	0	-	0	-
100° C	0	-	0	-
125°C	0	-	0	-
150°C	1	A	0	-
175°C	0	-	4	A
200°C	0	-	3	A
225°C	10	A	5	A
250°C	2	A	3	A
275°C	1	A	0	-
300°C	1	A	0	-

GROUP III 16 HR. TEMP. STEPS

TEST STEP T_A	MFR A		MFR B	
	QTY.	NOTE	QTY.	NOTE
150°C	0	-	0	-
175°C	0	-	0	-
200°C	1	D	0	-
225°C	1	E	0	-
250°C	1	A	3	A
275°C	0	-	2	A
300°C	2	A	3	A

MFR "A" = Motorola

MFR "B" = Siemens

NOTES:

(A) B_V minimum limit failure

(B) B_V maximum limit failure

(C) S/N 5180 missing device

(D) S/N 5271 removed from testing as MIL-STD-19500 limit failure

(E) S/N 5269 removed from testing as MIL-STD-19500 limit failure

APPENDIX A

FAILURE ANALYSIS

Power Stress

DCA

MSFC STEP-STRESS TEST
FAILURE ANALYSIS
DIODES
(Power Stress)

Date 6 December 1978

'N 2CN242-36A P/N 1N937B MFR Siemens

End Points:
4.28-14.18V

S/N	PIV -volts- @7.5±.01mA	I_r @ _____V.dc	V_f @ _____ dc		INITIAL REJ. @ Seq.#:	INITIAL REJ. FOR:
5 83	3.0 (S)				31 (150 % MRP 1510 Hrs.)	B_V
5 85	4.2 (S)				23 (125 % MRP 1050 Hrs.)	B_V
5188	2.05 (R)				33 (150 % MRP 1525 Hrs.)	B_V

INTERNAL DIE PROBE

S/N 5188 was opened on one side by grinding and internally probed. Starting from the anode end there were two forward and one reverse-biased diodes. The reverse diode junction is damaged. The breakdown voltages of the three dice in normal operation were: 0.3V (S), 0.5V (S), 1.3V (R). See Figure A-1.

INTERNAL VISUAL INSPECTION

No significant visual defects were seen.

*h_{FE} trace present. Cannot meet stated test conditions. (Leaky)

**h_{FE} trace very leaky.

D = drift H = hysteresis Inv = inversion R = resistive S = soft Uns = unstable

JANTX1N937B

MSFC STEP-STRESS TEST

FAILURE ANALYSIS

DIODES

(Power Stress)

Date 6 December 1978

N 2CN242-36A P/N 1N937B MFR Motorola

End Points:
4.28-14.18V

S/N	PIV -volts- @7.5±.01mA	I_r @ _____V.dc	V_f @ _____ dc		INITIAL REJ. @ Seq.#:	INITIAL REJ. FOR:
5 29	2.05 (S)				43 (175% MRP 2010 Hrs.)	B_V
5 30	1.50 (R)				49 (175% MRP 2150 Hrs.)	B_V
5236	2.7 (R)				37 (150% MRP 1650 Hrs.)	B_V

INTERNAL DIE PROBE

S/N 5236 was opened on one side by grinding and internally probed. Starting from the anode end there were two forward and one reverse biased diodes. The reverse diode junction is damage. The breakdown voltages of the three dice in normal operation were: 0.7V, 0.7V, 1.3V.

INTERNAL VISUAL INSPECTION

No significant visual defects were seen (see Figure A-2).

*h_{FE} trace present. Cannot meet stated test conditions. (Leaky)

**h_{FE} trace very leaky.

D = drift H = hysteresis Inv = inversion R = resistive S = soft Uns = unstable

CONCLUSIONS

These Siemens and Motorola diodes are constructed with the two anode dice forward biased and the cathode die reverse biased. When the case was partially ground away so that the internal structures could be probed, all anode (forward biased) dice were operational. The reverse-biased dice of all theses samples exhibited soft resistive curves. This indicates damage to the junctions due to micro-plasmas induced by the thermal and electrical stress of the burn-in. (See probe data above.)

CONCLUSIONS

These Siemens and Motorola diodes are constructed with the two anode dice forward biased and the cathode die reverse biased. When the case was partially ground away so that the internal structures could be probed, all anode (forward biased) dice were operational. The reverse-biased dice of all theses samples exhibited soft resistive curves. This indicates damage to the junctions due to micro-plasmas induced by the thermal and electrical stress of the burn-in. (See probe data above.)

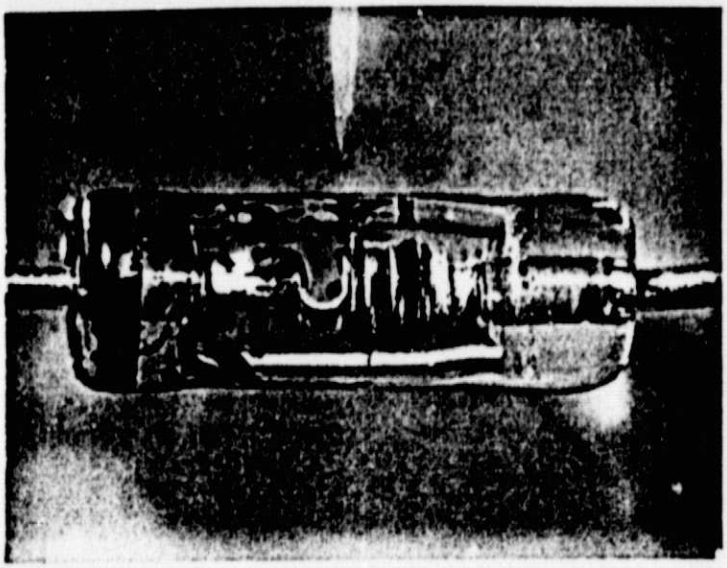

FIGURE A-1
S/N 5188. Typical Siemens Construction, 10X.

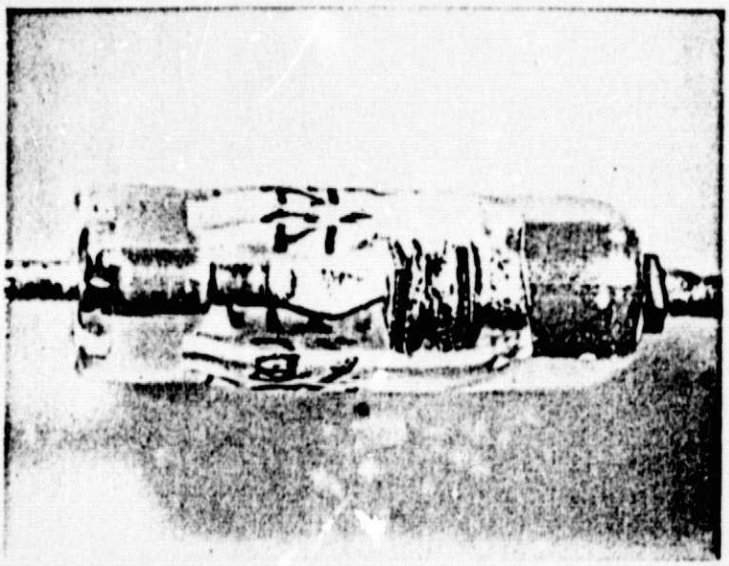

FIGURE A-2
S/N 5236. Typical Three-Dice Motorola Construction, 10X.

APPENDIX B

FAILURE ANALYSIS

Temperature Stress I

DCA

MSFC STEP-STRESS TEST
FAILURE ANALYSIS
DIODES
(160 Hours)

JANTX1N937B

Date 6 December 1978

N 2CN242-36B P/N 1N937B MFR Siemens

End Points:
4.28-14.18V

S/N	PIV -volts- @7.5±.01mA	I_r @ _____V.dc	V_f @ _____ dc		INITIAL REJ. @ Seq.#:	INITIAL REJ. FOR:
5190	3.1 (R)				11 (175°C 800 Hrs.)	B_V
5195	3.4 (R)				19 (275°C 1440 Hrs.)	B_V
5199	4.0 (R)				21 (300°C 1600 Hrs.)	B_V

INTERNAL DIE PROBE

S/N 5195 was opened on one side by grinding and internally probed. Starting from the anode end there were two forward and one reverse biased diodes. The reverse diode junction is damaged. The breakdown voltages of the three dice in normal operation were: shorted, 0.7V, and 2.7V. See Figure B-1.

INTERNAL VISUAL INSPECTION

No significant visual defects were seen.

*h_{FE} trace present. Cannot meet stated test conditions. (Leaky)
*h_{FE} trace very leaky.
D = drift H = hysteresis Inv = inversion R = resistive S = soft Uns = unstable

MSFC STEP-STRESS TEST
FAILURE ANALYSIS
DIODES
(160 Hours)

JANTX1N937B

Date 6 December 1978

'N 2CN242-36B P/N 1N937B MFR Motorola

End Points:
4.28-14.18V

'N	PIV -volts- @7.5±.01mA	I_r @ _____V.dc	V_f @ _____ dc		INITIAL REJ. @ Seq.#:	INITIAL REJ. FOR:
5 46	3.9 (R)				21 (300°C 1600 Hrs.)	B_V
5 49	3.0 (R)				19 (275°C 1440 Hrs.)	B_V
5 55	3.3 (R)				13 (200°C 960 Hrs.)	B_V

INTERNAL DIE PROBE

S/N 5255 was ground opened on one side and internally probed. Starting from the anode end there were two forward and one reverse-biased diodes. The reverse diode junction is damaged. The breakdown voltages of the three dice in normal operation were: 0.7V, 0.7V, 1.9V. See Figure B-2.

INTERNAL VISUAL INSPECTION

No significant visual defects were seen.

*h_{FE} trace present. Cannot meet stated test conditions. (Leaky)

**h_{FE} trace very leaky.

D = drift H = hysteresis Inv = inversion R = resistive S = soft Uns = unstable

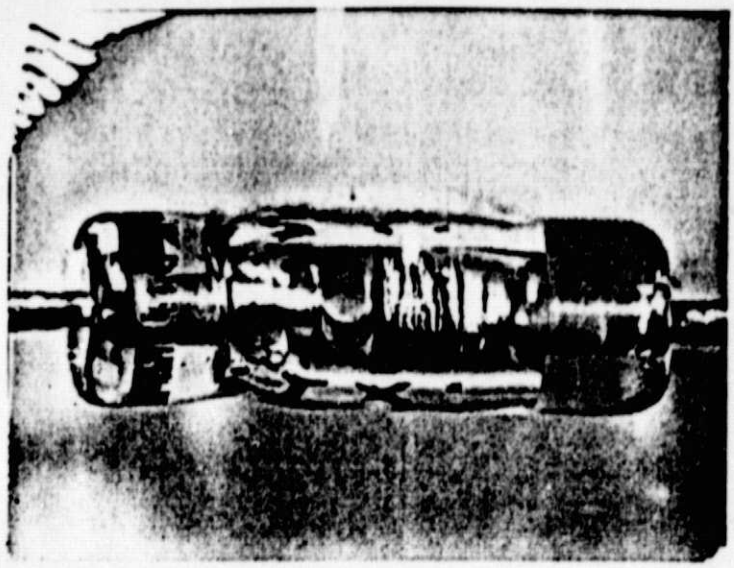

FIGURE B-1
S/N 5195. Typical three-dice
Siemens Construction, 10X.

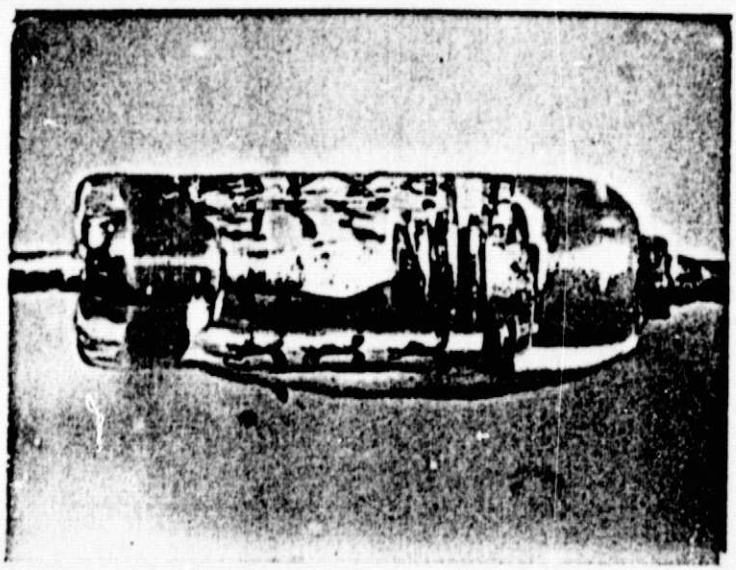

FIGURE B-2
S/N 5255. Typical three-dice
Motorola Construction, 10X.

CONCLUSIONS

These Siemens and Motorola diodes are constructed with the two anode dice forward biased and the cathode die reversed biased. When the case was partially ground away so that the internal structures could be probed, one anode (forward biased) die was operational. The reverse-biased dice of all these samples exhibited soft resistive curves. This indicates damage to the junctions due to micro-plasmas induced by the thermal and electrical stress of the burn-in. (See probe data above.)